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Effects of Musical Ability on Flight Planning, Situational Awareness, and Flight Path Deviations

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EFFECTS OF MUSICAL ABILITY ON FLIGHT PLANNING, SITUATIONAL
AWARENESS, AND FLIGHT PATH DEVIATIONS

By

Andrew P. Henry

A Thesis Submitted to the College of Aviation, School of Graduate Studies,
in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Aeronautics

Embry-Riddle Aeronautical University
Daytona Beach, Florida
December 2019

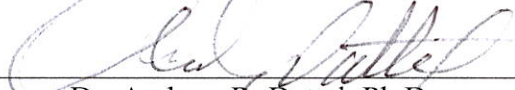
EFFECTS OF MUSICAL ABILITY ON FLIGHT PLANNING AND DECISION
MAKING

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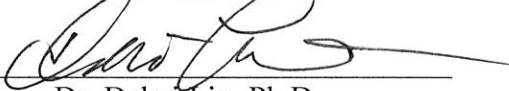
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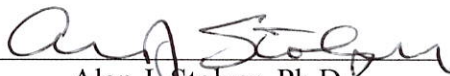


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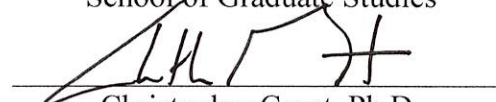
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Abstract

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Title: EFFECTS OF MUSICAL ABILITY ON FLIGHT PLANNING,
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Degree: Master of Science in Aeronautics

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Numerous studies have been conducted on music education and the benefits that learning an instrument has on the brain. However, there is little research that connects a pilot's ability to play an instrument to a pilot's ability to fly an airplane. When learning an instrument, students learn non-musical abilities, such as executive functions, which may correspond with the skills necessary to be a good pilot. The purpose of this study was to find a relationship between learning a musical instrument and pilot performance, specifically related to flight planning, situational awareness, and flight path deviations. This study was a quasi-experimental design studying 20 pilots with musical training and 20 pilots without musical training. Participants were assessed through a series of tests. The results showed no significant difference between the musical group and the non-musical group. However, participants with 5 or more years of musical experience performed better in flight planning, situational awareness accuracy, and airspeed deviations. Additionally, participants who learned music before the age of 8 performed better on flight planning and airspeed deviations than those who learned after the age of 8. Further research may investigate the relationship between age and length of training on pilot performance.

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Chapter I

Introduction

Anecdotally, it seems like all the smart kids in high school took band class. Did studying a musical instrument make them smarter, or do smart kids simply gravitate toward it? The “Mozart Effect” is a theory born from Dr. Alfred Tomatis’ studies on the benefits of music education on the brain. The idea is simple: listening to Mozart’s music for a short period of time increases a person’s ability to perform spatial reasoning tasks (Vitale, 2011). After this theory received national media attention (Schellenberg, 2001), a misconception was spread that “music makes you smarter.” The phenomenon, described as the “Mozart Effect,” was soon disclaimed when researchers found that mood arousal was the underlying reason for increased performance in participants during Dr. Tomatis’ studies. In fact, playing sad, slow music for participants before testing actually worsened participants’ performance (Thompson, Schellenberg, & Husain, 2001). Still, just the idea of the “Mozart Effect” has intrigued many researchers to study the effects of music on the brain. While simply listening to music may not have the cognitive benefits that were described above, research does show that musical training has both short and long-term effects on the human brain (Schellenberg, 2001). Schellenberg attempted to draw a comparison between these effects and pilot performance in a simulated environment.

Significance of the Study

The aviation industry is full of jobs that require employees to perform highly complex tasks. Of those, pilots are near the top of the list and require many cognitive abilities such as spatial awareness and problem-solving skills (Carretta et al., 2014).

Caretta et al. attempted to bridge a gap, comparing non-musically adept pilots and musically adept pilots in a series of tests to see whether or not musical ability is associated with better pilot performance. Admissions offices for flight schools, such as Embry-Riddle Aeronautical University (ERAU) could benefit from the present study in their attempt to find students who will most likely succeed in their flight programs. Findings from the present study could show musical ability as a predictor for student success in flight schools. Possible significant correlations could also help improve the hiring process for potential pilots, showing that they may possess higher levels of situational awareness (SA) and aeronautical decision making (ADM) skills. Results may also help training programs to better understand how to train pilots. Finally, the present study will add to the sparse research in pilot performance and musical ability.

Statement of the Problem

Numerous studies have been conducted on music education and the benefits that learning an instrument has on the brain. However, there is little research that connects a pilot's ability to play an instrument to his ability to fly a plane. The present study will attempt to answer whether or not pilots with musical training have stronger SA and ADM skills than pilots without musical training.

Purpose Statement

The goal of this research was to learn whether or not musically adept pilots perform better than their non-musician equivalents. In an attempt to answer this question, this thesis tested flight planning, situational awareness, and flight path deviations in both sets of pilots. Flight planning tests measured how effectively a pilot can put together a flight plan, while a flight simulator and questionnaire measured

situational awareness and flight path deviations. Data collected from these tests may establish evidence on whether or not having musical ability can predict better pilot performance.

Hypothesis

The following null hypotheses were tested:

H₀1: There will be no significant differences in flight planning scores between the musical group and the non-musical group.

H₀2: There will be no significant differences in situational awareness scores between the musical group and the non-musical group.

H₀3: There will be no significant differences in flight path deviations between participants in the musical group and non-musical group.

Delimitations

Samples were limited to participants with at least a private pilot's license but with no higher rating than an instrument rating. Participants in the musical group must have at least 2 years of musical training. For flight planning, participants were only given 30 minutes to create a flight plan due to time limitations.

Limitations and Assumptions

Participants were recruited from Embry-Riddle's student flight population. Due to differences in flight training, results may differ opposed to participants from other flight training schools. Due to the nature of self-reporting, musical ability demographics were approximate and may not be completely accurate. Participants may have received flight training at different flight schools which may have an effect on flight planning ability. After removing two questions from the situational awareness question section, a

maximum score of 5 created a range restriction. The small sample size limited analysis within the musical group with variables like “instrument type.” Flight students at ERAU are used to flight planning with a software known as Foreflight. Due to a limited budget, participants were required to use an E6B app and skyvector.com, which many participants were unfamiliar with. Participants’ unfamiliarity may have affected flight plan performance.

List of Acronyms

3P	Perceive, Process, Perform
5Ps	Plan, Plane, Pilot, Passengers, Programming
ADM	Aeronautical Decision Making
ANOVA	Analysis of Variance
ATC	Air Traffic Control
BATD	Basic Aviation Training Device
CARE	Consequences, Alternatives, Reality, External factors
CC	Corpus Callosum
CERTS	Cognitive Engineering and Research Transportation Systems
CF	Cognitive Flexibility
CFIT	Controlled Flight into Terrain
CRM	Crew Resource Management
DECIDE	Detect, Estimate, Choose course of action, Identify solutions, Do necessary actions, Evaluate effects of actions
E6B	Flight calculator
EF	Executive Functions

EFTO	Engine Failure upon Take Off
ERAU	Embry-Riddle Aeronautical University
ERP	Event Related Potential
FAA	Federal Aviation Administration
FPD	Flight Path Deviations
IGT	Iowa Gambling Task
IMSAFE	Illness, Medication, Stress, Alcohol, Fatigue, Emotion
MRI	Magnetic Resonance Imaging
NAVLOG	Navigation Log
NEPSY-II	Developmental Neuropsychological Assessment, Second Edition
PAVE	Checklist to mitigate risk standing for Pilot in command, Aircraft, enVironment, and External pressures
PHAK	Pilot's Handbook of Aeronautical Knowledge
RPD	Recognition Primed Decision
SA	Situational Awareness
SPAM	Situation Present Assessment Method
SPSS	Statistical Package for the Social Sciences
SRM	Single-Pilot Resource Management
SVS	Synthetic Vision Systems
TEAM	Transfer, Eliminate, Accept, Mitigate
TFR	Temporary Flight Restriction
TOMAL-2	Test of Memory and Learning, Second Edition
WM	Working Memory

Chapter II

Review of the Relevant Literature

Existing research shows that taking music lessons can increase brain activity and some non-musical skills. Schellenberg (2004) found that children who took music lessons scored higher on IQ tests than children who took drama or no classes. Wetter, Koerner, and Schwaninger (2009) found that music students in a Canadian school received better marks than their peers who were not in music class. Their research also suggests that the longer a student has studied music, the higher marks they received. Both of these studies were performed on children. To see the long-term effects of studying music on the brain, Gaser and Schlaug (2001) performed a T1-weighted MRI sequence to see the differences in gray matter between professional musicians and non-musicians. All musicians in the study had started their music training by the age of 10. The results of their study showed that the musicians had a higher volume of gray matter in the left and right sensorimotor regions of the brain. Deary (2012) states that there are several factors that influence intelligence. Some of these include health, economic status, education, age, and gender.

The tests mentioned above were done on children and professional musicians, respectively. Schellenberg (2011) advises researchers to be cautious when reading research studies on the effects of musical training because results will vary from children and adults, professional musicians and hobby musicians, and varying definitions of “music training.” Therefore, a thorough review of literature is required to decipher how musical training can affect the brain.

Shared Musician and Pilot Abilities

The goal of the current research is to find the skills and cognitive abilities that musicians hold and see how they compare to the skills that are required for safe and efficient piloting of an aircraft. Pilots require an array of skills to better perform their job both on the ground and in the sky. Just a few of these are: attention to detail, spatial awareness, problem solving, fine motor skills, advanced planning, and communication skills (Causse, Dehais, & Pastor, 2011). The research below suggests that many of these skills can be learned or enhanced by structured musical training.

Executive Functions

Merriam-Webster defines executive functions (EF) as “the group of complex mental processes and cognitive abilities (such as organizing tasks, remembering details, managing time, and solving problems) required for goal-directed behavior.” Causse, Dehais, and Pastor (2011) state that EFs are critical for piloting because it involves the pilot’s ability to navigate, maintain situational awareness, and execute strong decision-making skills. They even found that higher levels of EFs have been shown to predict better pilot performance in flight simulators. Diamond (2013) states that the three core EFs are inhibition, working memory, and cognitive flexibility. Slevc, Davey, Buschkuehl, and Jaeggi (2016) found that while musicians hold certain cognitive advantages, they are limited to only certain elements of EFs.

Inhibitory control. Pilots use inhibition by neglecting unimportant stimuli in the cockpit, keeping their attention focused on the tasks at hand, and thinking through problems instead of simply deciding on the first solution that comes to mind. Research shows that impulsivity, the opposite of inhibition, motivates individuals toward pursuing

higher risks (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001). For example, if a pilot experiences an engine failure upon take-off (EFTO), his or her impulse may be to turn the aircraft back around toward the airport. However, this maneuver has been termed “the impossible turn,” as it often leads to a stall or a loss of control, causing the aircraft to crash (US DOT, 1987). Even if the pilot succeeds in making the turn, he could endanger other departing aircraft from that same runway. Inhibition allows the pilot to neglect his or her impulse and begin working on a safer strategy to put the plane back on the ground.

Diamond (2013) states that inhibitory control is difficult for children. However, it is a skill that can be learned. Jäncke (2009) states that practicing a musical instrument daily can enhance EFs in a player. His research suggests that learning a musical instrument at an early age could possibly develop the cognitive abilities for children to learn inhibitory control sooner than their peers. Degê, Kubicek, and Schwarzer (2011) tested the effects of musical training on intelligence. Degê et al. tested 90 children ranging in age from 9 to 12 participated in the NEPSY-II test, a developmental neuropsychological assessment developed by Korkman, Kirk, & Kemp (2007). The NEPSY-II contains several subtests which assess cognitive abilities, including EFs, in children 3 to 16 years old. Parents of the participants were surveyed about the extent of their children’s musical training and for socioeconomic status. After scores were corrected for age, results showed a significant positive correlation between students who received musical training and higher levels of EFs such as inhibition and selective attention.

Working memory. Working memory (WM) is a part of the cognitive system that stores information for processing. It is the how one remembers relevant information while concurrently completing other tasks. An example of WM may be remembering a grocery list while driving to the store. Copious research has been conducted to figure out how WM is affected and how it can be greater used. A notable piece of literature on WM is the WM model developed by Baddeley and Hitch (1974). Their research model was used to replace previous models of short-term memory. It contained three main components. The first is the central executive, which acts as the head control system. The second two are slave systems, named the phonological loop and the visuo-spatial sketchpad, and are responsible for temporarily storing verbal information and visual and spatial information, respectively. Dual-task performance is explained by Baddeley and Hitch's model as tasks requiring use of different slave systems can be done easier than tasks requiring the same slave system. Baddeley (2000) adds a third slave system to the model called the episodic buffer. The episodic buffer is still controlled by the central executive, but acts as an interface for the two aforementioned slave systems, integrating information from each system.

In the aviation industry, WM affects highly dynamic tasks such as air traffic control and flying. Flying requires interpretation and integration of new information in a rapidly changing environment, making WM a critical component of successful piloting (Causse et al., 2011). It is also important in regards to following air traffic control instructions, as a single clearance may have several commands to follow including airspeed, altitude, and headings (Gateau, Durantin, Lancelot, Scannella, & Dehais, 2015; Taylor, O'Hara, Mumenthaler, Rosen, & Yesavage, 2005). A lack of WM capacity can

increase the risk of an accident because only limited information provided can be processed. In an emergency situation, a pilot must analyze the situation and react swiftly and efficiently to fix the problem. Jipp (2016) studied pilots and their ability to prevent cognitive lock-ups, a concept where an initial failure is followed by successive failures due to the operator's fixation on the initial failure. Jipp showed that participants with lower WM reacted slower to consecutive failures in a simulator, while participants with higher WM reacted quicker. Jipp suggests that pilots with stronger WM may handle more increased workloads before encountering a cognitive lockup than those with lower WM capacity. Indeed, Sohn and Doane (2004) showed that WM affects situational awareness and can predict performance in a flight simulator. Their study states that WM is critical for novice pilots, while long term WM is more critical for expert pilots who rely on previous experiences as well as knowledge in order to maintain safe flight.

A study on neural correlates of EFs in musicians found that adult musicians who started playing an instrument by the age of 9 years old and currently practiced an average of 8 hours per week scored better on measures of WM than non-musicians. Age, gender, and IQ were not significantly different (Zuk et al., 2014). George and Coch (2011) used an Event Related Potential (ERP) test and the Second Edition of the Test of Memory and Learning (TOMAL-2) to distinguish differences in WM between musicians and non-musicians. Results showed that musicians with long-term training performed better on auditory and visual WM. An interesting study on learning the piano in order to minimize cognitive decline in the elderly showed that piano instruction increased cognitive abilities, including WM, after 6 months of training. However, 3 months after the training discontinued, the cognitive benefits were no longer sustained (Bugos, Perlstein, McCrae,

Brophy, & Bedenbaugh, 2007). The above research suggests that consistent practice of an instrument may increase WM in a musician. Perhaps practicing an instrument acts as a workout for the brain, increasing WM capability.

Cognitive flexibility. Cognitive flexibility (CF) is another element of EF which pilots should possess. Cognitive flexibility is responsible for actions such as task-switching, being able to see things in a different perspective, and being able to adjust to priorities when the situation arises (Diamond, 2013). A pilot is required to perform several tasks over the course of a flight such as speed and altitude adjustments, turning the airplane, communicating with copilots and air traffic controllers (ATC), monitoring the array of instruments in front of them, and identifying traffic or other potential hazards to the flight. During an emergency, a pilot may be required to devise a new strategy when previously desired options are taken away. Pilots must have strong CF to perform the tasks above. Research shows significant correlations between flight performance and CF in that pilots with lower CF scores were more likely to deviate from a flight path (Bentham & Herdman, 2016). Another study by Ji, Xu, Xu, Du, and Li (2018) found that flying cadets with higher levels of CF held better situational judgment. The findings from Ji et al. furthered the importance of CF stating that flying requires more cognitive processing and uses CF for strategy selection.

Learning a musical instrument demands many executive functioning skills including task-switching CF, goal-directed behavior, and sustained attention (Slama, Rebillon, & Kolinsky, 2017; Zuk, Benjamin, Kenyon, & Gaab, 2014). Research shows a mixed opinion on whether or not musicians have stronger CF than non-musicians (Clayton et al., 2016). Still, there are studies that present stronger performance of CF,

WM, and even processing speed in musicians when extensive training is involved (Zuk et al., 2014).

Situational Awareness

Flying an airplane is a highly complex and dynamic task. It is imperative for pilots to observe and collect information pertaining to their flight and safety over time and use that information with their knowledge in order to achieve an end goal. This construct is termed situational awareness (SA). There are three levels of SA: perceiving, comprehending, and predicting. In the cockpit, a pilot must perceive information such as instrument readings, traffic, the outside environment, and ATC instructions. After perceiving **this** information, the pilot puts together a mental picture of the entire situation including all the factors from the first step. Finally, the pilot must create a projection of the future events to recognize possible conflicts (Endsley, 1995).

SA is a crucial skill that pilots must possess in order to safely and efficiently fly an airplane. Consequently, many studies have been conducted in the aviation industry regarding the importance of SA and how to improve it. Bolten, Bass, and Comstock (2007) found that synthetic vision systems (SVS) help increase SA by increasing spatial awareness. SVS are a technology that create a computerized 3D reality giving pilots an enhanced understanding of their environment. This technology can reduce pilot errors such as controlled flight into terrain (CFIT).

The U.S. Army has made over 500 improvements to certain cockpit designs in order to decrease workload and increase SA (Hicks, Durbin, Morris, & Davis, 2014). New technologies have been developed which aid pilots in their SA. For example, ADS-B is a satellite surveillance system which helps pilots understand their geographical

position, and the glass cockpit is a digital instrument display which consolidates the original cluster of gauges into a screen. SVS, and other technology, have reduced workload and therefore increased SA among pilots (Esler, 2006).

Situational awareness is a construct that is affected by multiple facets of cognitive abilities that one uses in order to assess their surroundings (Endsley, 1995). There is evidence that certain EFs, especially WM, contribute to SA (Carretta, Perry, & Ree, 1996; Endsley, 1995; Saus et al., 2009; Sohn & Doane, 2004). Research shows that spatial reasoning and attention are key elements in good SA (Carretta, Perry, & Ree, 1996; Parush, 2017). Many of these cognitive abilities can be found in musicians.

Spatial reasoning. Rauscher, Shaw, and Ky (1993) and Rauscher et al. (1997) suggest that music can alter spatial-temporal reasoning. In the Rauscher et al. study, participants were asked to listen to Mozart, relaxation instructions, or sit in silence for 10 minutes. Then, they were given spatial reasoning tasks from the Stanford-Binet Intelligence Scale Test. Participants given the Mozart treatment scored significantly higher than the relaxation or silence groups. As mentioned before, mood arousal could be an explanation for the study from Rauscher et al. However, in the second study, researchers tested preschool students on spatial reasoning tasks, then applied a different treatment to three different groups. Treatments were piano lessons, singing lessons, computer lessons, and there was an untreated control group. Each group was tested 6 months after the treatment. Of the four groups, only the piano lesson group scored high enough to yield significance in spatial-temporal tasks. These studies suggest that music, especially piano lessons, can improve spatial-temporal reasoning. Carretta, Perry, and

Ree (2009) found that after flight hours were controlled for, spatial reasoning was a cognitive ability predictive of SA in F-15 pilots.

Selective attention. Selective attention is the practice of intentionally reacting to numerous stimuli over a course of time. Selective attention enhances a pilot's SA by filtering out unimportant stimuli and quickly observing important stimuli in and out of the cockpit. Jipp (2016) found that pilots with higher levels of sustained attention and WM were less likely to experience a cognitive lock-up while encountering consecutive failures in a simulated cockpit due to their quicker reaction times to each failure.

Degê, Kubicek, and Schwarzer (2011) found significant results showing that music lessons enhanced selective attention. They also found that those with higher selective attention did better on the intelligence tests, suggesting the relationship between music lessons and IQ can be attributed to selective attention and other EFs. Bugos et al. (2007) found that along with WM, attention and concentration can be improved by individualized piano instruction.

Aeronautical Decision-Making

Another widely studied concept in pilot performance, which is different yet related to SA, is Aeronautical Decision Making (ADM). ADM is such an important concept in aviation performance that the Federal Aviation Administration (FAA) dedicated a chapter to it in their handbook, Pilot's Handbook of Aeronautical Knowledge (PHAK) (US DOT, 2016). According to the PHAK, ADM is "a systematic approach to the mental process used by pilots to consistently determine the best course of action in response to a given set of circumstances" (PHAK, 2-1). An estimated 80% of aviation accidents are a result of pilot error, usually related to human factors. In order to

overcome this alarming statistic, both the airlines and the FAA have been working on programs to increase ADM.

The programs focus on efficiently using all resources at the pilot's disposal in order to mitigate risks, and they are all covered in the PHAK. Of these are Crew Resource Management (CRM) and Single-Pilot Resource Management (SRM). Both involve utilizing on-board resources such as auto-pilot, checklists, or other technology and outside resources such as ATC to mitigate risks while flying. On top of resource management, risk management mnemonics were also created including IMSAFE, which helps a pilot decide if they are physically, mentally, and emotionally fit to fly; PAVE, which helps pilots determine preflight if conditions are adequate for safe flying; CARE, which helps pilots assess risks; and TEAM, which helps pilots manage risk. DECIDE is another decision-making process that a pilot can use to detect a problem, estimate the need to react to it, choose a desired outcome, identify the actions necessary to achieve said outcome, do the actions, and evaluate the effect of his actions. If the problem still exists, he can start the process over again. For single pilot operations, the 5Ps decision-making model was created which focuses on five areas of the flight where a problem may occur. These are the plan, the plane, the pilot, the passengers, and the programming, and they should be checked at preflight, before takeoff, in flight, and before final descent. A much simpler decision-making model is the 3P Model which states a pilot should perceive his or her situation, process the impact it has on safety, and perform the actions necessary for safe flight.

Situational awareness and ADM draw from many of the same concepts as the other. While they share similarities, they are still different. However, Endsley (1995)

states that good SA can sometimes lead to better decision-making. Klein (1993) released a model known as the Recognition-Primed Decision (RPD) model which is made up of two parts. The first part involves recognizing the strategy required in a situation. The second part involves mentally evaluating the strategy to predict the outcome. RPD supports experience as a main factor in rapid decision-making. An expert can more quickly recognize a situation and implement the correct decision, but novices may have to cycle through several decisions before implementing an ultimate decision. The RPD model integrates SA and mental simulation to produce a decision. Therefore, it is possible that musicians who truly possess the cognitive abilities that enrich SA may have the ability to make better decisions.

Hou, He, Chen, and Dong (2017) studied the effect of musical training on decision making and found that participants with early musical training performed better than those with late or no musical training. This study from Hou et al. was a part of a larger study where 567 students from Beijing Normal University took the Iowa Gambling Task (IGT), a decision-making test, and several other cognitive tests. Of these students, 42 said they received musical training by the age of 7, 52 received training after age 8, and a control group of 60 participants had no musical training. Researchers ran a one-way ANOVA which showed significant differences between the three groups on the IGT test. The post hoc analysis found that the group with early musical training performed better than the other two groups. Their study also tested for WM, and they found that participants with early musical training tested significantly better on WM than those without musical training. Findings from Hou et al. support other research that early musical training may create long-term changes in the brain. Thus, it is likely that pilots

who received musical training at an early age may perform better than pilots who received musical training later or have no musical ability at all.

Other Musician Advantages

Fine motor skills. Musicians require fine motor skills in order to play their instruments. A study by Costa-Giomi (2005) showed that after 2 years of piano instruction, children scored significantly better than a non-musical control group on the response speed section of the Bruinsky-Oseretsky Motor Proficiency Test. Costa-Giomi suggests that the instant and continuous feedback a musician receives after they play a note may improve response time in perceiving and reacting to stimuli. Although Costa-Giomi's research does not support better fine motor skills in musicians, it may contribute to a musically inclined pilot being able to maintain their course more decisively as they can perceive and react to deviations from the course quicker.

Auditory reaction timing. In addition to spatial reasoning skills, Landry and Champoux (2017) found that musicians had better reaction times to auditory stimuli compared to a non-musician control group. Musicians can also detect and distinguish between auditory stimuli quicker than non-musicians (Schellenberg, 2001). Pilots must distinguish between many alerts, engine noise, ATC instructions, and each other in the cockpit. The auditory benefits from being a musician may increase communication skills in pilots.

Corpus callosum. As mentioned previously, Degê et al. (2011) found that musicians learn EF skills that aid in the ability to solve problems. The corpus callosum (CC) is a band of fibers that connect the left and the right side of the brain together. Schlaug, Jäncke, Huang, Steiger, and Steinmetz (1995) showed that musicians who began

their lessons by age 7 have a thicker anterior half of the CC. It is their speculation that the consistent bimanual motor coordination practice required to learn an instrument may increase the size of the CC. The corpus callosum is divided into separate regions, each responsible for connecting different parts of the left and right hemisphere of the brain. The above research does not specify which region is enlarged by the training, so it is unclear how the musical training may affect the brain's ability to transfer information between the hemispheres. However, Luders et al. (2007) show that a larger CC may increase performance and intelligence by allowing the brain to process information quicker between hemispheres. The increased CC may aid in problem-solving while planning a flight or while in-flight.

Measuring Situational Awareness

There have been many methods over the past few decades on how to measure SA. One of the first methods is from Endsley (1995) involving the SAGAT battery. SAGAT stands for Situation Awareness Global Assessment Technique. To better understand, we must first understand Endsley's definition of situational awareness. She states that there are three levels that make up SA: perceiving information, understanding information, and predicting future events based on said information. During a flight simulation, Endsley would pause the scenario and ask the participant a battery of questions. These questions address each level of SA and are measured by errors made by the participant.

Another SA measurement, the Situation Present Assessment Method (SPAM) asks questions in real-time while the operator is still performing the task (Durso & Dattel, 2004). Accuracy and response time (RT) are the measured variables in SPAM. Theoretically, the participant should answer the questions more quickly if they are

situationally aware. If they know where to look for the answer, it will take longer, but if they don't know where to look for the answer, it will take even longer. The benefit of using SPAM over SAGAT is that the researcher will have an additional measure, response time, in addition to accuracy.

Measuring Flight Path Performance

Flight path performance is how well the pilot can maintain an assigned heading, speed, and altitude. It can be measured by deviations from the assigned parameter. Many studies have used the flight path deviations (FPD) approach to assess pilot performance (Bentham & Herdman, 2016; Causse, Dehais, & Pastor, 2011; Taylor et al., 2000). The current study will use a variation of FPD based on previous studies in order to measure flight performance.

Summary

Existing research shows that musicians and pilots may share some cognitive abilities and skills necessary to perform their tasks. Pilots require SA, ADM, and many cognitive abilities such as EFs that enable them to fly safely and efficiently. Musical training may increase EFs and encourage the mental development in a musician's brain. These developments may contribute to cognitive processes that create stronger SA and ADM. Executive functions such as inhibitory control, WM, and CF have been shown to increase pilot performance. Musical training has been shown to be correlated with higher levels of EFs. Situational awareness can be influenced by spatial awareness, selective attention, and more. Spatial awareness and selective attention have both been seen to increase with musical training. ADM is critical for flight performance, and research shows that stronger SA may contribute to better ADM. Musicians hold benefits such as

fine motor skills, better auditory reaction timing, and a possibly larger CC which may augment a pilot's ability to command an aircraft. Existing literature supports the argument that it is plausible that a musically trained pilot may perform better than their non-musically trained peers.

Chapter III

Methodology

Participants

The sample size for this experiment was 40 participants. A power analysis was conducted using G*Power 3.1 before the experiment to determine the sample size. A treatment group of 20 participants was required to have a history of at least 2 years of musical training. The non-equivalent control group consisted of 20 participants with less than 2 years of musical training. Participants were recruited by several means. First, participants were solicited from Embry-Riddle's Music Club and Aeronautical Science classes. Second, one flyer was posted around Embry-Riddle Aeronautical University's campus. The flyer asked for candidates who have a private pilot's license with or without an instrument rating. The flyer can be found in Appendix A. Using this sample, results from this experiment can be generalized toward collegiate-level flight students.

Design and Procedure

To begin the experiment, participants were briefed on what they could expect from the experiment and asked to sign the participant consent form found in Appendix B. Then, a pen and paper survey was issued to all participants. The survey included open-ended and partially open-ended questions about musical training and flight experience. Survey questions can be found in Appendix C. After completing the survey, participants were asked to create a flight plan from New Smyrna Municipal Airport (KEVB) to Northeast Florida Regional Airport (KSGJ). Printed instructions were given to the participants for the flight plan and can be found in Appendix D. A desktop computer in the lab was opened to Skyvector.com using Google Chrome for participants' use. In

addition, an iPad was given to the participants with an E6B application running on it. Participants were allowed up to 30 minutes to create the flight plan using no more than three waypoints (not including the origin and destination airports) and finding the most direct path (least miles) from the origin to destination. The participants were given a fabricated weather forecast and NOTAM which can be found in Appendices E and F, respectively. Participants were allowed to use the website skyvector.com on one of the laboratory computers, an E6B app on an iPad, NAVLOG sheets (Appendix G), Cessna 172 performance charts (Appendix H), and a pencil. To save time, weight and balance forms were already completed for the participant, as well as sections of the NAVLOG.

After completing the flight plan, participants were asked to step into the flight simulator. The simulator was an Elite-PI 135 Basic Aviation Training Device (BATD) located in the Cognitive Engineering in Research Transportation Systems (CERTS) Lab at Embry-Riddle Aeronautical University. The software used was X-Plane 11.

Participants flew a C-172 Skyhawk, an aircraft used for flight training at ERAU.

Participants were given up to 5 minutes to become familiar with the simulator in a free flight. After the participant felt ready, the researcher loaded a premade flight scenario.

The scenario began with the aircraft in-flight paused over Daytona Beach International Airport at a cruising altitude of 3,500 feet with a heading of 350° and an airspeed of 110 knots. The researcher told the participant to maintain the heading of 350°, the altitude of 3,500 feet, and the airspeed of 110 knots. The researcher also instructed the participants that they should expect to hear questions coming through a headset and that they should answer these questions as quickly and accurately as possible through the headset microphone. A total of seven questions were asked approximately

every 2 minutes. Questions can be found in Appendix I. When the participant was ready, the researcher simultaneously played the simulation and began the playback and recording process on Audacity. The participant then proceeded to fly the flight path and answer the questions asked through his headset. One minute after the last question was asked, the researcher paused the simulation. The participant was then debriefed on the experiment, paid \$10.00, and thanked for their time. The debriefing can be found in Appendix J. After the participant left the room, the researcher saved the flight data from the simulation.

Apparatus and materials. Materials needed for the cross-country flight planning were a sectional chart and plotting tool, an E6B flight computer, a weather briefing, a NAVLOG, Cessna 172 performance charts, and a pen. The sectional chart and plotting tool were electronic and can be found on skyvector.com. The E6B flight computer was an app on an iPad. For the flight simulation, participants operated the simulation training device located in the CERTS Lab at Embry-Riddle Aeronautical University. The flight simulator used the X-Plane 11 flight simulation software. This software allows the researchers to create, save, and load flight scenarios using various aircraft models, airspaces, weather settings, and even simulated failures. X-Plane also has a built-in data collection device which can be read by copying and pasting the text file into Microsoft Excel. The software collected data from parameters such as time elapsed, various speeds, headings, and altitudes, and more. An audio recording software, Audacity, was used to ask and record answers to situational awareness questions. Audacity allowed the researcher to pre-record an audio track, then later simultaneously record a separate audio track while the first one was playing. Therefore, a headset was

required for the participant to hear and respond to the questions. To analyze the data, SPSS and Microsoft Excel software was used.

Treatment of the Data

The design of this research was quasi-experimental as the participants could not be randomly assigned due to the preexisting condition of musical training. The test was a between-subjects design. The survey contained several open-ended questions. Numeric answers were entered into SPSS as such. Non-numeric answers were coded and inserted into SPSS for analysis. For example, a yes or no question was coded as a “1” and a “2” in SPSS. Musical instruments were grouped into broader categories. For example, brass and woodwind instruments were categorized as “Wind.” Violins, cellos, guitars, and bass guitars were categorized as “String.” Piano and keyboard instruments were categorized as “piano.” These categories were coded as numeric values into SPSS.

Data collected from the flight planning section were analyzed for accuracy. The instructions stated to find the most direct route given the circumstances provided. Data collected were whether or not the participant flew a correct route. Flight path deviations were recorded by the X-Plane 11 software, copied and pasted into a Microsoft Excel document, and then transferred into SPSS. X-Plane 11 records several data, but the heading, indicated airspeed, and altitude were used for analyzation to determine deviations. X-Plane 11 recorded 10 points of data in each second. For situational awareness, the SPAM was used. These data were collected by subtracting the timestamp of the answer from the timestamp of the question. In addition to time, accuracy data were collected. These data were scored as correct or incorrect and will be coded into SPSS.

Chapter IV

Results

Data were collected on a sample of 41 participants. However, one participant consistently failed to follow instructions, so that participant's data were omitted. The sample consisted of 20 participants in the musical group and 20 participants in the non-musical group for a total of 40 participants ($N = 40$). There were 8 females and 32 males in the sample. Data were collected for the number of total flight hours for the musical group ($M = 151.44$, $SD = 61.08$), the non-musical group ($M = 146.39$, $SD = 76.96$), and for the total sample ($M = 148.66$, $SD = 69.44$). The difference in flight hours between groups was not significant. Flight experience ranged from 54 to 300 total flight hours. Mean flight hours for each group can be found in Figure 1.

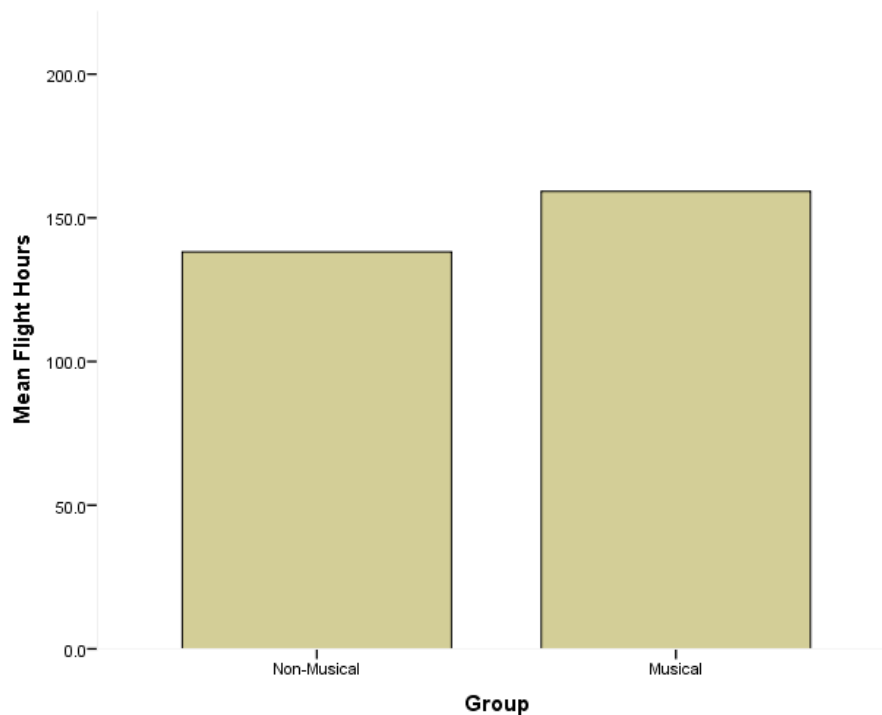


Figure 1. Frequency of flight hours for musical and non-musical groups.

Within the musical group, data were collected for the average age at which participants began learning a musical instrument ($M = 9.35$, $SD = 3.50$) and for the average length (in years) for which they trained ($M = 6.03$, $SD = 4.21$).

Between Musical and Non-Musical Groups

Flight planning. Due to the nature of flight planning, there are often several correct solutions. This study attempted to limit the amount of correct solutions by placing restrictions on where a participant could plan their route. For example, participants could not fly below 2,500 feet or above 3,500 feet due to weather and a TFR. Therefore, data were collected on whether the participants' flight plans were a plausible solution or not based on the restrictions given.

In the musical group, 10 participants chose correct flight routes, and 10 participants chose incorrect flight routes. In the non-musical group, 14 participants chose correct routes, and 6 participants chose incorrect flight routes. A chi-square test for independence was computed at the .05 significance level to test the null hypothesis that having a musical background and correctly planning the flight were independent. The results did not show a significant association between the factors, $\chi^2(1) = 1.66$, $p = .20$, and thus the null hypothesis was retained.

Situational awareness. Participants were asked seven situational awareness questions during their simulated flight. Of these, two questions were omitted due to the difficulty of the questions. Data for one participant in the non-musical group were lost, so only 19 participants are included in the non-musical group. Data were collected on whether or not the participants gave the correct answer and how long it took the

participants to state the correct answer. Table 1 shows the average scores for accuracy and latency between the musical group and the non-musical group.

Table 1

Situational Awareness Questions

	Group	N	Mean	Std. Deviation
Latency ^a	Musical	20	3.3872	1.28480
	Non-Musical	19	3.2650	1.59463
Total Correct	Musical	20	4.3000	.73270
	Non-Musical	19	4.5263	.61178

^aLatency shown in seconds

When analyzing latency, the mean for the musical group ($M = 3.39$, $SD = 1.28$) was not different from the mean for the non-musical group ($M = 3.27$, $SD = 1.59$). An independent samples t -test was not significant at an α level of .05, $t(37) = 0.026$, $p = .79$. Therefore, the null hypothesis was retained.

When analyzing the total number of correct answers, the mean for the musical group ($M = 4.30$, $SD = 0.73$) was not different from the mean for the non-musical group ($M = 4.53$, $SD = 0.61$). An independent samples t -test was not significant at an α level of .05, $t(37) = 1.04$, $p = .30$. Therefore, the null hypothesis was retained.

Flight Path Deviations. Participants were asked to fly a heading of 105° , an altitude of 3,500 feet, and an airspeed of 105 knots during the flight simulation. Ten data points were collected per second for each parameter. The first 60 seconds of all data were omitted due to the flight software beginning the flight at an unstable airspeed. The omission allowed participants 60 seconds to ensure their flight path was correct. To find

the deviations, the data collected for each parameter were subtracted from the target values, then an absolute value was found for each datum. The resulting absolute values were averaged together to find the mean flight path deviations. This calculation was done for all three parameters. Table 2 shows the average flight path deviations for each group.

Table 2

Flight Path Deviations

	Group	<i>N</i>	Mean	Std. Deviation
Altitude ^a	Musical	20	15.9403	15.19467
	Non-Musical	20	27.0028	41.05918
Airspeed ^b	Musical	20	3.2485	2.10281
	Non-Musical	20	5.0082	4.95166
Heading ^c	Musical	20	2.6156	1.88557
	Non-Musical	20	4.6895	9.51451

^a Altitude shown in feet, ^b Airspeed shown in knots, ^c Heading shown in degrees

When analyzing the altitude deviation, the mean for the musical group ($M = 15.94$, $SD = 15.19$) was not different from the mean for the non-musical group ($M = 27.00$, $SD = 41.06$). An independent samples t -test was not significant at an α level of .05, $t(38) = 1.13$, $p = .27$. Therefore, the null hypothesis was retained.

When analyzing the airspeed deviation, the mean for the musical group ($M = 3.25$, $SD = 2.10$) was not different from the mean for the non-musical group ($M = 5.01$, $SD = 4.95$). An independent samples t -test was not significant at an α level of .05, $t(38) = 1.46$, $p = .15$. Therefore, the null hypothesis was retained.

When analyzing the heading deviation, the mean for the musical group ($M = 2.62$, $SD = 1.89$) was not different from the mean for the non-musical group ($M = 4.69$, $SD = 9.51$). An independent samples t -test was not significant at an α level of .05, $t(38) = 0.96$, $p = .35$. Therefore, the null hypothesis was retained.

Length of Musical Training

The previous analyses focused on the musical group which had 2 or more years of training. Within that group, data were collected on how many years each participant had played their respective instruments ($M = 6.03$ years, $SD = 4.21$). The range was from 2 to 16 years of playing. A Pearson's correlation coefficient was computed at an α level of .05 to evaluate the relationship between the amount of years a participant played their musical instrument and SA and FPD variables. A significant positive correlation was found between the number of years a participant played their instrument and accuracy for situational awareness questions, $r(18) = .527$, $p = .017$. For further analysis, the musical group was then divided into two groups. One group, "5 or more," had 5 or more years of training ($M = 9.3$, $SD = 3.59$) and the other group, "under 5," had less than 5 years of training ($M = 2.7$, $SD = 0.79$). This analysis was based on a study from George and Coch (2011) showing that a proficiency in an instrument may have an effect on executive functions.

Flight Planning. The "5 or more" group chose the correct flight path eight times and the incorrect flight path two times. The "under 5" group chose the correct flight path two times and the incorrect flight path eight times. A chi-square test for independence was computed at an α level of .05 to test whether having more or less than five years of

music training and flight planning were independent. The results showed a significant association between factors, $\chi^2(1) = 7.2, p = .007; \phi = .6$.

Situational Awareness. Situational awareness data were analyzed between the group with more than 5 years of training and the group with less than 5 years of training. Descriptive statistics for the two groups are in Table 3.

Table 3

Situational Awareness Within the Musical Group

	Years Musical		Mean	Std. Deviation
	Training	<i>N</i>		
SA Accuracy	Under 5	8	3.8750	.64087
	More than 5	12	4.5833	.66856

An independent samples *t*-test was computed at an α level of .05 to test whether having more or less than 5 years of music training had an effect on the total number of situational awareness questions a participant answered correctly. The mean of the “under 5” group ($M = 3.88, SD = 0.64$) was smaller than the mean of the “5 or more” group ($M = 4.59, SD = 0.67$). An independent samples *t*-test was significant, $t(18) = 2.36, p = .030$. Cohen’s $d = 1.08$. Mean SA accuracy scores can be found in Figure 2.



Figure 2. Mean SA accuracy scores between “under 5” and “5 or more” groups.

Flight path deviations. Flight path deviation data were analyzed between the “under 5” and “5 or more” groups. Average deviations from altitude, airspeed, and heading are shown in Table 4.

Table 4

Average Flight Path Deviations Within the Musical Group

	Years Musical Training	<i>N</i>	Mean	Std. Deviation
Altitude ^a	Under 5	8	13.3036	9.32444
	5 or More	12	17.6980	18.30393
Airspeed ^b	Under 5	8	4.7531	2.03553
	5 or More	12	2.2454	1.50229
Heading ^c	Under 5	8	2.8018	2.16673
	5 or More	12	2.4915	1.76395

^a Altitude shown in feet; ^b Airspeed shown in knots; ^c Heading shown in degrees.

When analyzing the altitude, the mean for the “under 5” group ($M = 13.30$, $SD = 9.32$) was not different from the mean for the “5 or more” group ($M = 17.70$, $SD = 18.30$). An independent samples t -test was not significant at an α level of .05, $t(18) = .62$, $p = .541$.

When analyzing the airspeed, the mean for the “under 5” group ($M = 4.75$, $SD = 2.04$) was larger than the mean for the “5 or more” group ($M = 2.25$, $SD = 1.50$). An independent samples t -test was significant at an α level of .05, $t(18) = 3.18$, $p = .005$. Cohen’s $d = 1.40$. Mean scores between the “under 5” and “5 or more” groups can be found in Figure 3.

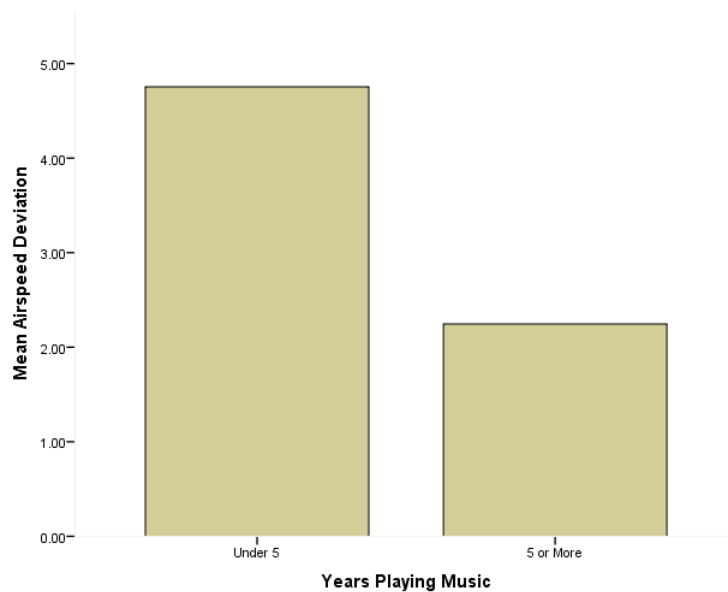


Figure 3. Mean airspeed deviations between “under 5” and “5 or more” groups.

When analyzing the heading, the mean for the “under 5” group ($M = 2.80$, $SD = 2.17$) was not different from the mean for the “5 or more” group ($M = 2.49$, $SD = 1.76$).

An independent samples t -test was not significant at an α level of .05, $t(18) = .35$, $p = .729$.

Age at Which Participants Began Learning Music

Data were collected within the musical group for the age at which participants began learning a musical instrument ($M = 9.35$, $SD = 3.50$). Ages ranged from 5 to 16 years old. The musical group was divided into two groups based on previous research (Zuk et al, 2014; Hou, He, Chen & Dong, 2017; Schlaug, Jäncke, Huang, Steiger & Steinmetz, 1995) which showed that students who learned music by the age of 8 sometimes performed better on cognitive tasks than the students who learned after 8 years old. The two groups were those who learned music before the age of 8 and those who learned music at or above the age of 8. Means for the two groups' SA and FPD scores are listed in Table 5.

Table 5

SA and FPD Means for Age of Training

	Age Began Music	<i>N</i>	Mean	Std. Deviation
Altitude ^a	Below 8	8	21.2665	21.60677
	At or Above 8	12	12.3894	8.20455
Airspeed ^b	Below 8	8	1.7710	1.27599
	At or Above 8	12	4.2335	1.98880
Heading ^c	Below 8	8	2.2083	2.04871
	At or Above 8	12	2.8871	1.80806
SA Accuracy	Below 8	8	4.3750	.74402
	At or Above 8	12	4.2500	.75378
SA Latency ^d	Below 8	8	3.7870	1.34556
	At or Above 8	12	3.1206	1.22689

^a Altitude shown in feet; ^b Airspeed shown in knots; ^c Heading shown in degrees; ^d Latency shown in seconds.

Flight Path Deviations. An independent t -test was conducted for each of the FPD parameters and for SA accuracy and latency. No significant results were found except for airspeed deviations, $t(18) = 3.09$, $p = .006$, Cohen's $d = 1.47$. Mean airspeed deviations between the “at or above 8” group and “below 8” group can be found in Figure 4.

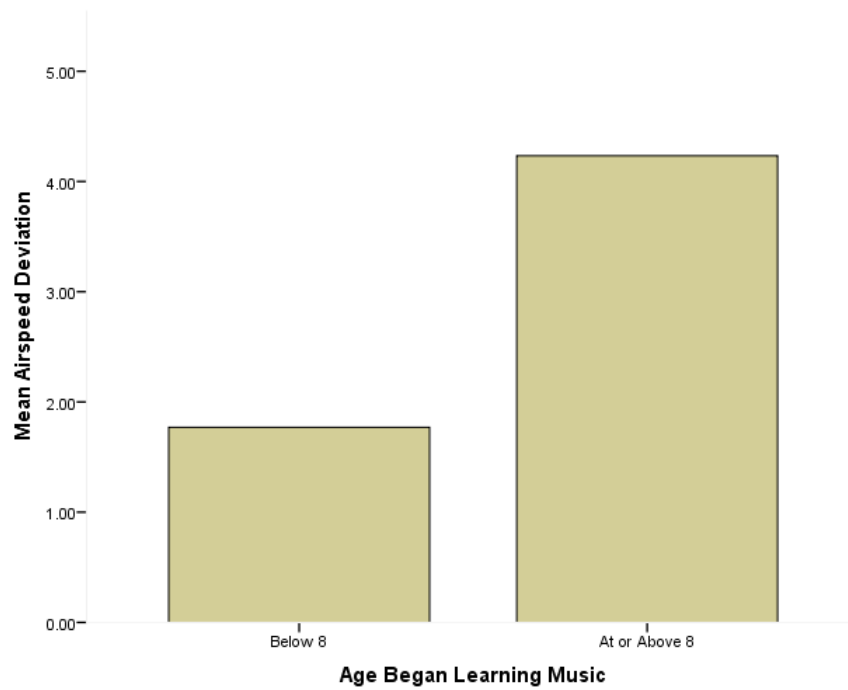


Figure 4. Mean airspeed deviations between “below 8” and “at or above 8” groups.

Flight planning. Of the 12 participants in the “at or above 8” group, 3 chose the correct flight path. Of the 8 participants in the “below 8” group, 7 chose the correct flight path. A chi-square test for independence was computed at the .05 level of significance to test whether or not learning music below or at or above the age of 8 was independent from choosing a correct flight plan. The result showed a significant association between the factors, $\chi^2(1) = 7.5$, $p = .006$; $\phi = .61$.

Type of Instrument

Data were collected on which type of instrument each participant in the musical group played to see if a particular instrument was more likely to cause a difference in the flight planning tests. Instruments were categorized into Wind, String, and Piano. Other instruments, such as percussion, were not found in this study. A one-way analysis of variance (ANOVA) showed that there was no significance between the type of instrument and SA latency, SA accuracy, or FPD variables (See Table 6 for F-table).

Table 6

One-Way ANOVAs for Type of Instrument and SA and FPD Variables

		<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
SA Latency ^a	Between	1.946	2	.973	.562	.580
	Within	29.418	17	1.730		
	Total	31.363	19			
SA Accuracy	Between	.350	2	.175	.302	.743
	Within	9.850	17	.579		
	Total	10.200	19			
Altitude ^b	Between	171.332	2	85.666	.345	.713
	Within	4215.349	17	247.962		
	Total	4386.681	19			
Airspeed ^c	Between	7.686	2	3.843	.856	.442
	Within	76.329	17	4.490		
	Total	84.014	19			
Heading ^d	Between	4.417	2	2.209	.595	.563
	Within	63.135	17	3.714		
	Total	67.552	19			

^a Latency shown in seconds; ^b Altitude shown in feet; ^c Airspeed shown in knots;

^d Heading shown in degrees.

Chapter V

Discussion, Conclusions, and Recommendations

Discussions

The results of this study show that having musical training does not affect pilot performance in regards to flight planning, SA, or FPD. The results found between the “under 5” and “5 or more” groups may suggest that only having 2 to 5 years of music training may actually hinder flight planning, SA, and FPD. However, this finding warrants further research because some of the participants in the non-musical group may have had up to but not including 2 years of musical training which the analysis did not account for.

Musical vs Non-Musical. There were no significant differences between the musical group and non-musical group in any of the flight planning, SA, or FPD assessments. Of all the musically experienced pilots, only two participants reported still practicing their instrument. Bugos et al. (2007) showed that 3 months after quitting instrument lessons, any increases in cognitive functions declined. The literature may explain why participants who no longer practice their instruments did not score significantly better than the non-musical group.

It is well-known that ERAU is an academically vigorous university. Higher levels of executive functions have been shown to be predictive of academic success (Zuk et al, 2014). It is possible that any advantages the musical group may have had over a normal population were negated due to the competitive and rigorous nature of being a successful student at ERAU, resulting in a ceiling effect within the sample in executive functions.

Length of music training. The results found in the current study are supported by those of George and Coch (2011) that having extensive musical training may promote stronger performance in using certain executive functions, such as working memory. The present study found significant results between the “under 5” and “5 or more” groups in SA accuracy, flight planning, and airspeed deviations. Age was not taken into effect, so it could be possible that the participants who played their instrument longer are simply older, more experienced, or are further cognitively developed than younger participants. Therefore, it is likely that the greater experience seen in the “5 or more” group produced better results than the “under 5” group. Klein’s (1993) RPD model showing that experience leads to a stronger decision-making ability supports the present study’s findings. It is possible that the key to maximizing cognitive benefits from music training may be proficiency in the instrument.

Flight planning. Essentially, the flight plan assessed a participant’s ability to solve problems. The typical route a pilot would fly was blocked by either a TFR or inclement weather. Participants would have to extract critical information from several sources to piece together a mental image of the airspace restrictions and then create an alternative solution. This process would require using executive functions such as inhibitory control and selective attention. The “5 or more” group scored significantly better on this assessment than the “under 5” group. These findings are in line with studies from Degê, Kubicek, and Schwarzer (2011) showing that musical ability can increase inhibitory control and selective attention among other executive functions.

Situational awareness. Situational awareness has been shown to increase with stronger working memory (Carretta, Perry, & Ree, 1996; Endsley, 1995; Saus et al.,

2009; Sohn & Doane, 2004). The group which had 5 or more years of musical training scored significantly better on SA accuracy than the “under 5” group. This evidence is supported by George and Coch (2011) showing that extensive music training may increase WM in a participant, therefore increasing their SA.

Airspeed deviations. Controlling FPD is critical for pilot performance. It is a highly tactile function of pilot performance to be aware of an aircraft’s shifts and to correct them. Similarly, playing an instrument requires the same tactile ability of being aware of the slight changes in pitch or timing and minutely adjusting finger positioning or tempo accordingly. Of the parameters observed, airspeed requires the most attention as many factors, including pitch and power may affect the airspeed. According to Namowitz (1999), “the ability to use airspeed correctly is testimony to a pilot's skill.” In this sample, the “5 or more” group deviated significantly less than the “under 5” group. These results are supported by previous studies (Bugos et al., 2007; Degê, Kubicek, & Schwarzer, 2011) that having musical experience increases selective attention in a player. Although the “under 5” group did have musical ability, it is possible that to attain the higher selective attention process required to notice and adjust minute details, a higher proficiency in music may be required.

Age at which participants began learning music. Several studies have been conducted on how learning music by a specific age affects cognitive functions in a child. Degê et al. (2011) found significant results in youth from age 9 to 12. Zuk et al. (2014) found significant results in youth by the age of 9. Hou et al. (2017) found significance in youth by the age of 7. These studies support the results of the present study. Participants in the musical group were divided into two groups. One group learned music before the

age of 8 (“below 8”) and the other group learned music at or above the age of 8 (“at or above 8”). This study found significant results favoring the “at or above 8” group in flight planning and airspeed deviations. These results are in line with previous research that learning a musical instrument at an early age may increase cognitive functions in a player. However, this finding may also suggest that learning an instrument at or above the age of 8 may encumber pilot performance. As mentioned earlier, data for those who learned an instrument for less than 2 years were not included in this analysis, which confounds the previous statement.

Recommendations

College admissions offices, especially those seeking candidates for highly complex degrees, must select the best candidates within a highly competitive pool. Many students grow up learning extra-curricular activities such as music, sports, technology, and others. It would be beneficial for admissions offices to know what kind of cognitive skills these students are learning in addition to simply learning how to play an instrument or play a sport. Further research could be conducted on which types of extra-curricular activities promote stronger pilot performance.

Similarly, further research on this topic could investigate related aviation fields like air traffic control which also requires strong cognitive abilities. Results from a study focusing on air traffic control could benefit not only Embry-Riddle’s admission process, but also the hiring process by the FAA to see what kind of extra-curricular activities promote stronger air traffic management performance.

In this study, there was not enough variation in the type of musical instruments played to find any relationship between pilot performance and the type of instrument a

participant played or if a student pilot still practices their instrument weekly. Future studies may investigate how learning different instruments affects cognitive functions or pilot performance

Furthermore, it would be interesting to see how performing in a band environment influences CRM in the cockpit. In an orchestral environment, musicians are led by a single conductor who keeps the band together. However, in smaller ensembles, such as a jazz trio or string quartet, musicians share a greater responsibility to work together and perform a piece of music. Many times, hired musicians will have never worked together, similar to professional pilots, and they must find a way to function as a team to execute their respective tasks. Further research could be conducted on how performing in an ensemble affects CRM management.

Several studies have been conducted on how the age at which a participant learns a musical instrument affects cognitive functions. However, the results are still not clear at which age or how long a player needs to have musical training before attaining stronger cognitive functions. Future research may examine how age and length of training affects cognitive functions.

Conclusions

This study tried to find a relationship between having musical ability and pilot performance. The first set of analyses focused on two groups. The first group, the musical group, had at least 2 years of musical training. The second group had no musical experience or less than 2 years. While scores trended toward the music group in FPD, no significant results were found between these two groups suggesting that there is no difference between pilot performance and having musical ability. The second set of

analyses were conducted on two subgroups of the music group. These two subgroups were separated by having 5 or more years of music training (“5 or more”) and having less than 5 years of music training (“under 5”). Results found that the “5 or more” group scored significantly better on SA accuracy, on airspeed deviations, and on flight planning, suggesting that there may be a benefit to having a proficiency in an instrument compared to simply learning an instrument. The third set of analyses divided the musical subgroup by the age at which participants learned an instrument. The group that started music lessons before the age of 8 scored significantly better on airspeed deviations and flight planning than the group that started music lessons at the age of 8 or later. This analysis suggests that learning an instrument at an early age may increase cognitive functions required for flight planning and maintaining course. However, these studies did not factor in those who had less than 2 years of musical experience and future research should investigate further how age and length of musical training truly affects pilot performance.

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Appendix A
Fliers for Recruitment



HAVE YOU EVER PLAYED A MUSICAL INSTRUMENT?

~~~~~  
**LOOKING FOR CANDIDATES  
TO PARTICIPATE IN  
RESEARCH STUDY  
\$10 FOR ONE HOUR STUDY**

## **PARTICIPANT REQUIREMENTS**

Must be 18 years or older

Must have a private pilot's license with or without an  
instrument rating

Must have 1 year of experience learning a musical instrument

**If interested, please contact Andrew Henry at [HenryA10@my.erau.edu](mailto:HenryA10@my.erau.edu)**



# Pilots Needed for Research Study!

**Requirements: Must have private pilot's license with or without instrument rating. Must be 18 years or older.**

**\$10 for a one-hour research study**

**Contact Andrew Henry at [HenryA10@my.erau.edu](mailto:HenryA10@my.erau.edu) if interested!**

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**Appendix B**  
**Consent to Research**

INFORMED CONSENT FORM  
The Effect of Musical Ability on Pilot Performance

**Purpose of this Research, expected duration and description of the procedures:** The purpose of this research is to find out how pilots with a musical ability differ from pilots without musical ability by testing flight planning, situational awareness, and flight path deviations. The study is expected to last no longer than one hour. For the first 5 minutes, you will fill out a survey. The next 30 minutes, you will complete a flight plan. Finally, you will fly a 20 minute flight simulation.

**ELIGIBILITY:** To participate in this study, you must be 18 years of age or older and possess a valid Federal Aviation Administration private pilot certificate with or without an instrument rating.

**Risks or discomforts:** You will be flying a flight-simulator; therefore, you may experience some dizziness. However, the chances of this are small. The simulation has no motion aspect to it. The simulator is a desktop simulator using X-Plane 11. It will be very similar to simply playing a video game. If, at any point, you don't feel comfortable using the simulator, we ask that you discontinue the study.

**Benefits:** The benefit of participating in this study is to help us understand whether or not there is a difference in pilot performance between pilots with and without musical ability.

**Confidentiality of records:** Your information will be kept confidential. Any data collected will be saved under a participant number, and not your name. This data will be stored separately from the consent form. There will be no way to connect any data collected to an individual. Publication of any data will not include any identifying information.

**Compensation:** You will be given \$10.00 for your participation in this study.

**Contact:** If you have questions or would like additional information about the study, please contact the researcher, Andrew Henry at [HenryA10@my.erau.edu](mailto:HenryA10@my.erau.edu). For any concerns or questions as a participant in this research, contact the Institutional Review Board (IRB) at 386-226-7179 or via email [teri.gabriel@erau.edu](mailto:teri.gabriel@erau.edu).

**Voluntary Participation:** Your participation in this study is completely voluntary. You may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. Should you wish to discontinue the research at any time, no information collected will be used, and you will still receive compensation for your time.

**Participant Privacy:** Any personal information that can identify you will be removed from the data collected and this data will **not** be used or distributed for **future research studies**.



**Consent:** By signing below, I certify that I am a resident of the US and I am 18 years of age or older. I further verify that I understand the information on this form, that the researcher has answered any and all questions I have about this study, and I voluntarily agree to participate in the study.

Signature of Participant \_\_\_\_\_ Date \_\_\_\_\_

Printed Name of Participant \_\_\_\_\_

## **Appendix C**

### **Survey Questions**

**Participant Number:** \_\_\_\_\_

How many total flight hours have you logged to date? \_\_\_\_\_

What is your gender? \_\_\_\_\_

Do you or have you ever played a musical instrument?      Yes      No

**If no**, you may stop now and turn this in to your researcher.

At which age did you begin playing an instrument? \_\_\_\_\_

Do you currently practice an instrument?      Yes      No

If yes, how many hours a week do you practice your instrument? \_\_\_\_\_

Which instrument(s) can/did you play? \_\_\_\_\_

\_\_\_\_\_

How did you learn how to play that instrument? If you play more than one, specify each instrument followed by the type of learning (school, private lessons, self-taught, etc).

\_\_\_\_\_

How many years have/did you practice that instrument? Again, if you play more than one instrument, specify which instrument and from which ages you played for.

\_\_\_\_\_

**Appendix D**  
**Flight Plan Instructions**

### Flight Plan Instructions

You will be given 20 minutes to create a flight plan as you normally would before flying a solo flight. However, your flight will be limited to **three waypoints** (excluding the origin and destination airports). Please create your flight plan so that the route is the **most direct** (least miles). To save time, the weight and balance has been created for you.

A fabricated weather report and a fabricated NOTAM will be given to you. You will also receive a few Cessna 172 performance charts to reference. You may use skyvector.com as a plotting tool and sectional chart. You may use the E6B app on the iPad for your calculations.

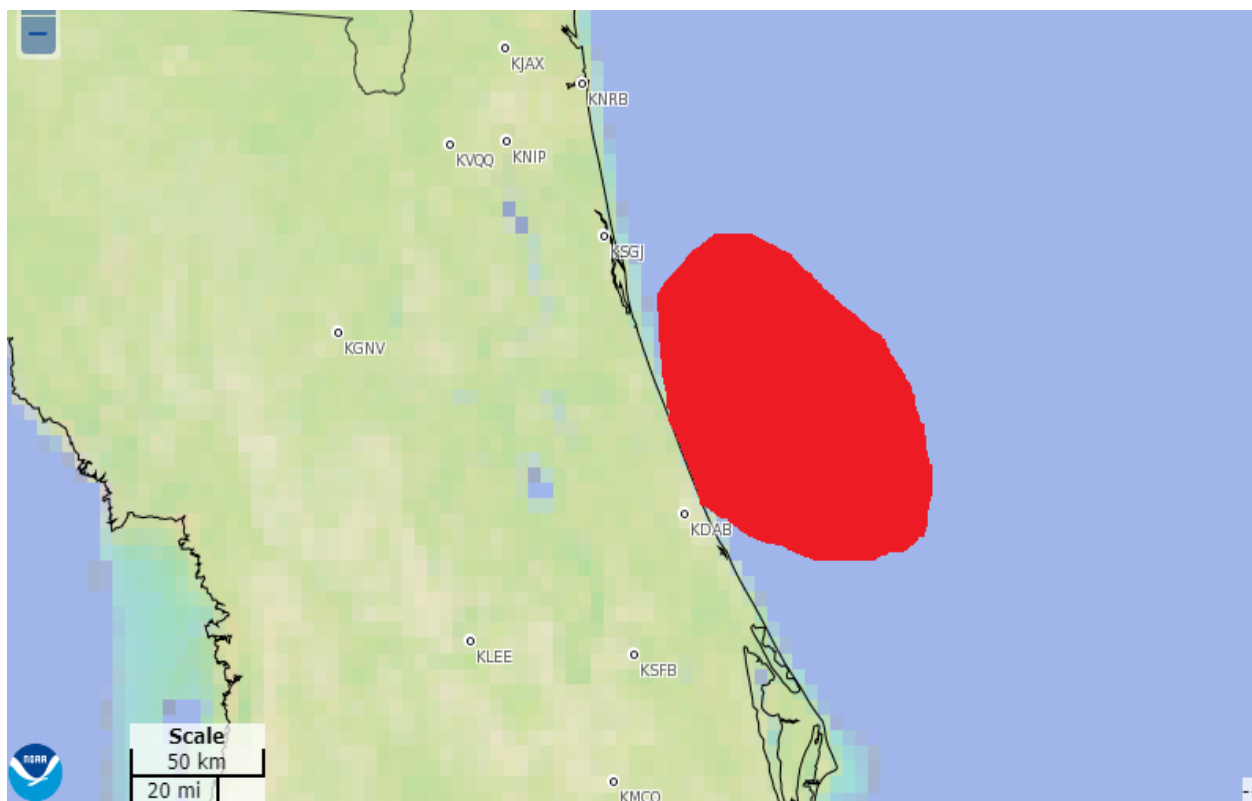
Please create your flight plan using the provided NAVLOG.

Origin: New Smyrna Municipal Airport (KEVB)

Destination: Northeast Florida Regional Airport (KSGJ)

Estimated Departure Time: 1700Z

**Appendix E**  
**Fabricated Weather Report**



\*Red area depicts ominous weather unsuitable for VFR flight

\*\*Winds Aloft Calm

\*\*\*No AIRMETs/SIGMETs

#### **METARs**

KDAB 151653Z 26008G12KT 6SM VCRA BKN040 29/19 A3002

KSGJ 151656Z 29007G12KT 8SM SCT045 31/19 A3002

KEVB 151647Z 26008G12KT 6SM VCRA BKN040 29/19 A3002

KFIN 151650Z 27007G12KT 6SM VCRA BKN040 29/19 A3002

KOMN 151649Z 26008G12KT 6SM VCRA BKN040 29/19 A3002

#### **TAFs**

KDAB 151350Z 1420/1520 27010G13KT P6SM -RA BKN045

FM151600 26008G12KT P6SM VCRA BKN040

FM151800 25007G10KT P6SM BKN040

KSGJ 151332Z 1421/1521 31010KT P6SM SCT040

FM151600 VRB02KT P6SM SCT045

FM151800 30005KT P6SM FEW050

**METAR for:** KDAB (Daytona Beach Intl, FL, US)

**Text:** KDAB 151653Z 26008G12KT 6SM VCRA BKN040 29/19 A3002

**Temperature:** 29°C ( 84°F)

**Dewpoint:** 19°C ( 66°F)

**Pressure (altimeter):** 30.02 inches Hg

**Winds:** from the W (260 degrees) at 9 MPH (8 knots) gusting at 14 MPH (12 knots)

**Visibility:** 6 SM  
**Ceiling:** 4,000 feet AGL  
**Clouds:** broken clouds at 4,000 feet AGL

**TAF for:** KDAB (Daytona Beach Intl, FL, US)

**Text:** KDAB 151350Z 1420/1520 27010G13KT P6SM -RA BKN045

**Forecast period:** 1350 UTC 15 March 2019 to 1600 UTC 15 March 2019

**Forecast type:** FROM: standard forecast or significant change

**Winds:** from the W (270 degrees) at 11 MPH (10 knots) gusting at 15 MPH (13 knots)

**Visibility:** 6 SM

**Ceiling:** 4500 feet AGL

**Clouds:** broken clouds at 4500 feet AGL

**Weather:** VCRA (rain in vicinity)

**Text:** FM151600 26008G12KT P6SM VCRA BKN040

**Forecast period:** 1600 UTC 15 March 2019 to 1800 UTC 15 March 2019

**Forecast type:** FROM: standard forecast or significant change

**Winds:** from the W (260 degrees) at 9 MPH (8 knots) gusting at 14 MPH (12 knots)

**Visibility:** 6 SM

**Ceiling:** 4000 feet AGL

**Clouds:** broken clouds at 4000 feet AGL

**Weather:** VCRA (rain in vicinity)

**Text:** FM151800 25007G10KT P6SM BKN040

**Forecast period:** 1800 UTC 15 March 2019 to 2000 UTC 15 March 2019

**Forecast type:** FROM: standard forecast or significant change

**Winds:** from the W (250 degrees) at 8 MPH (7 knots) gusting at 12 MPH (10 knots)

**Visibility:** 6 SM

**Ceiling:** 4000 feet AGL

**Clouds:** broken clouds at 4000 feet AGL

---

**METAR for:** KSGJ (St Augustine Arpt, FL, US)

**Text:** KSGJ 151656Z 29007G12KT 8SM SCT045 31/19 A3002

**Temperature:** 31°C ( 88°F)

**Dewpoint:** 19°C ( 66°F)

**Pressure (altimeter):** 30.02 inches Hg

**Winds:** from the W (290 degrees) at 8 MPH (7 knots) gusting at 14 MPH (12 knots)

**Visibility:** 8 SM

**Ceiling:** 4,500 feet AGL

**Clouds:** scattered clouds at 4,500 feet AGL

**TAF for:** KSGJ (St Augustine Arpt, FL, US)

**Text:** KSGJ 151332Z 1421/1521 31010KT P6SM SCT040

**Forecast period:** 1332 UTC 15 March 2019 to 1600 UTC 15 March 2019

**Forecast type:** FROM: standard forecast or significant change

**Winds:** from the W (310 degrees) at 11 MPH (10 knots)

**Visibility:** 6 SM



**Ceiling:** 4500 feet AGL

**Clouds:** scattered clouds at 4000 feet AGL

**Text:** FM151600 VRB02KT P6SM SCT045

**Forecast period:** 1600 UTC 15 March 2019 to 1800 UTC 15 March 2019

**Forecast type:** FROM: standard forecast or significant change

**Winds:** variable at 2 MPH (2 knots)

**Visibility:** 6 SM

**Ceiling:** 4500 feet AGL

**Clouds:** scattered clouds at 4500 feet AGL

**Text:** FM151800 30005KT P6SM FEW050

**Forecast period:** 1800 UTC 15 March 2019 to 2000 UTC 15 March 2019

**Forecast type:** FROM: standard forecast or significant change

**Winds:** from the W (300 degrees) at 6 MPH (5 knots)

**Visibility:** 6 SM

**Ceiling:** 5000 feet AGL

**Clouds:** few clouds at 5000 feet AGL

---

**METAR for:** KEVB (New Smyrna Beach Mun, FL, US)

**Text:** KEVB 151647Z 26008G12KT 6SM VCRA BKN040 29/19 A3002

**Temperature:** 29°C ( 84°F)

**Dewpoint:** 19°C ( 66°F)

**Pressure (altimeter):** 30.02 inches Hg

**Winds:** from the W (260 degrees) at 9 MPH (8 knots) gusting at 14 MPH (12 knots)

**Visibility:** 6 SM

**Ceiling:** 4,000 feet AGL

**Clouds:** broken clouds at 4,000 feet AGL

---

**METAR for:** KFIN (Palm Coast/Flagler C, FL, US)

**Text:** KFIN 151650Z 27007G12KT 6SM VCRA BKN040 29/19 A3002

**Temperature:** 29°C ( 84°F)

**Dewpoint:** 19°C ( 66°F)

**Pressure (altimeter):** 30.02 inches Hg

**Winds:** from the W (270 degrees) at 8 MPH (7 knots) gusting at 14 MPH (12 knots)

**Visibility:** 6 SM

**Ceiling:** 4,000 feet AGL

**Clouds:** broken clouds at 4,000 feet AGL

---

**METAR for:** KOMN (Ormond Beach Mun, FL, US)

**Text:** KOMN 151649Z 26008G12KT 6SM VCRA BKN040 29/19 A3002

**Temperature:** 29°C ( 84°F)

**Dewpoint:** 19°C ( 66°F)

**Pressure (altimeter):** 30.02 inches Hg

**Winds:** from the W (260 degrees) at 9 MPH (8 knots) gusting at 14 MPH (12 knots)

**Visibility:** 6 SM

**Ceiling:** 4,000 feet AGL

**Clouds:** broken clouds at 4,000 feet AGL

---

**Appendix F**  
**Fabricated NOTAM**

**NOTAM NUMBER: APH2019**

Issue Date: February 2, 2019 at 1457 UTC  
Location: FLAGLER EXECUTIVE AIRPORT, Bunnell,  
Florida  
Beginning Date and Time: February 2, 2019 at 1500 UTC  
Ending Date and Time: April 31, 2019 at 1500 UTC  
Reason for NOTAM: Temporary flight restrictions for Special Security  
Reasons  
Type: Security

**AFFECTED AREAS**

## Airspace Definition

Center: FLAGLER EXECUTIVE AIRPORT (Latitude: N29°27.91',  
Longitude: W81°12.46')  
Radius: 3 Nautical Miles  
Altitude: From the surface up to 3000 feet AGL

**Appendix G**  
**NAVLOG Sheet**



**Appendix H**  
**Cessna 172 Performance Charts**

SECTION 5  
PERFORMANCE

CESSNA  
MODEL 172S

**SHORT FIELD TAKEOFF DISTANCE  
AT 2550 POUNDS**

CONDITIONS:

Flaps 10°  
Full Throttle Prior to Brake Release  
Paved, level, dry runway  
Zero Wind  
Lift Off: 51 KIAS  
Speed at 50 Ft: 56 KIAS

| Press<br>Alt<br>In<br>Feet | 0°C                |                                          | 10°C               |                                          | 20°C               |                                          | 30°C               |                                          | 40°C               |                                          |
|----------------------------|--------------------|------------------------------------------|--------------------|------------------------------------------|--------------------|------------------------------------------|--------------------|------------------------------------------|--------------------|------------------------------------------|
|                            | Grnd<br>Roll<br>Ft | Total<br>Ft To<br>Clear<br>50 Ft<br>Obst | Grnd<br>Roll<br>Ft | Total<br>Ft To<br>Clear<br>50 Ft<br>Obst | Grnd<br>Roll<br>Ft | Total<br>Ft To<br>Clear<br>50 Ft<br>Obst | Grnd<br>Roll<br>Ft | Total<br>Ft To<br>Clear<br>50 Ft<br>Obst | Grnd<br>Roll<br>Ft | Total<br>Ft To<br>Clear<br>50 Ft<br>Obst |
| S. L.                      | 860                | 1465                                     | 925                | 1575                                     | 995                | 1690                                     | 1070               | 1810                                     | 1150               | 1945                                     |
| 1000                       | 940                | 1600                                     | 1010               | 1720                                     | 1090               | 1850                                     | 1170               | 1990                                     | 1260               | 2135                                     |
| 2000                       | 1025               | 1755                                     | 1110               | 1890                                     | 1195               | 2035                                     | 1285               | 2190                                     | 1380               | 2355                                     |
| 3000                       | 1125               | 1925                                     | 1215               | 2080                                     | 1310               | 2240                                     | 1410               | 2420                                     | 1515               | 2605                                     |
| 4000                       | 1235               | 2120                                     | 1335               | 2295                                     | 1440               | 2480                                     | 1550               | 2685                                     | 1660               | 2880                                     |
| 5000                       | 1355               | 2345                                     | 1465               | 2545                                     | 1585               | 2755                                     | 1705               | 2975                                     | 1825               | 3205                                     |
| 6000                       | 1495               | 2605                                     | 1615               | 2830                                     | 1745               | 3075                                     | 1875               | 3320                                     | 2010               | 3585                                     |
| 7000                       | 1645               | 2910                                     | 1785               | 3170                                     | 1920               | 3440                                     | 2065               | 3730                                     | 2215               | 4045                                     |
| 8000                       | 1820               | 3265                                     | 1970               | 3575                                     | 2120               | 3880                                     | 2280               | 4225                                     | 2450               | 4615                                     |

NOTES:

1. Short field technique as specified in Section 4.
2. Prior to takeoff from fields above 3000 feet elevation, the mixture should be leaned to give maximum RPM in a full throttle, static runup.
3. Decrease distances 10% for each 9 knots headwind. For operation with tail winds up to 10 knots, increase distances by 10% for each 2 knots.
4. For operation on dry, grass runway, increase distances by 15% of the "ground roll" figure.

Figure 5-5. Short Field Takeoff Distance (Sheet 1 of 3)



SECTION 5  
PERFORMANCE

CESSNA  
MODEL 172S

**TIME, FUEL AND DISTANCE TO CLIMB  
AT 2550 POUNDS**

CONDITIONS:

Flaps Up  
Full Throttle  
Standard Temperature

| PRESS<br>ALT<br>FT | CLIMB<br>SPEED<br>KIAS | RATE<br>OF<br>CLIMB<br>FPM | FROM SEA LEVEL    |                     |            |
|--------------------|------------------------|----------------------------|-------------------|---------------------|------------|
|                    |                        |                            | TIME<br>IN<br>MIN | FUEL<br>USED<br>GAL | DIST<br>NM |
| S.L.               | 74                     | 730                        | 0                 | 0.0                 | 0          |
| 1000               | 73                     | 695                        | 1                 | 0.4                 | 2          |
| 2000               | 73                     | 655                        | 3                 | 0.8                 | 4          |
| 3000               | 73                     | 620                        | 4                 | 1.2                 | 6          |
| 4000               | 73                     | 600                        | 6                 | 1.5                 | 8          |
| 5000               | 73                     | 550                        | 8                 | 1.9                 | 10         |
| 6000               | 73                     | 505                        | 10                | 2.2                 | 13         |
| 7000               | 73                     | 455                        | 12                | 2.6                 | 16         |
| 8000               | 72                     | 410                        | 14                | 3.0                 | 19         |
| 9000               | 72                     | 360                        | 17                | 3.4                 | 22         |
| 10,000             | 72                     | 315                        | 20                | 3.9                 | 27         |
| 11,000             | 72                     | 265                        | 24                | 4.4                 | 32         |
| 12,000             | 72                     | 220                        | 28                | 5.0                 | 38         |

NOTES:

1. Add 1.4 gallons of fuel for engine start, taxi and takeoff allowance.
2. Mixture leaned above 3,000 feet for maximum RPM.
3. Increase time, fuel and distance by 10% for each 10°C above standard temperature.
4. Distances shown are based on zero wind.

Figure 5-7. Time, Fuel and Distance to Climb

CESSNA  
MODEL 172S

SECTION 5  
PERFORMANCE

### CRUISE PERFORMANCE

CONDITIONS:  
2550 Pounds  
Recommended Lean Mixture At All Altitudes (Refer to Section 4, Cruise)

| PRESS<br>ALT<br>FT | RPM  | 20°C BELOW<br>STANDARD TEMP |      |      | STANDARD<br>TEMPERATURE |      |      | 20°C ABOVE<br>STANDARD TEMP |      |     |
|--------------------|------|-----------------------------|------|------|-------------------------|------|------|-----------------------------|------|-----|
|                    |      | %<br>BHP                    | KTAS | GPH  | %<br>BHP                | KTAS | GPH  | %<br>BHP                    | KTAS | GPH |
| 2000               | 2550 | 83                          | 117  | 11.1 | 77                      | 118  | 10.5 | 72                          | 117  | 9.9 |
|                    | 2500 | 78                          | 115  | 10.6 | 73                      | 115  | 9.9  | 68                          | 115  | 9.4 |
|                    | 2400 | 69                          | 111  | 9.6  | 64                      | 110  | 9.0  | 60                          | 109  | 8.5 |
|                    | 2300 | 61                          | 105  | 8.6  | 57                      | 104  | 8.1  | 53                          | 102  | 7.7 |
|                    | 2200 | 53                          | 99   | 7.7  | 50                      | 97   | 7.3  | 47                          | 95   | 6.9 |
|                    | 2100 | 47                          | 92   | 6.9  | 44                      | 90   | 6.6  | 42                          | 89   | 6.3 |
| 4000               | 2600 | 83                          | 120  | 11.1 | 77                      | 120  | 10.4 | 72                          | 119  | 9.8 |
|                    | 2550 | 79                          | 118  | 10.6 | 73                      | 117  | 9.9  | 68                          | 117  | 9.4 |
|                    | 2500 | 74                          | 115  | 10.1 | 69                      | 115  | 9.5  | 64                          | 114  | 8.9 |
|                    | 2400 | 65                          | 110  | 9.1  | 61                      | 109  | 8.5  | 57                          | 107  | 8.1 |
|                    | 2300 | 58                          | 104  | 8.2  | 54                      | 102  | 7.7  | 51                          | 101  | 7.3 |
|                    | 2200 | 51                          | 98   | 7.4  | 48                      | 96   | 7.0  | 45                          | 94   | 6.7 |
|                    | 2100 | 45                          | 91   | 6.6  | 42                      | 89   | 6.4  | 40                          | 87   | 6.1 |
| 6000               | 2650 | 83                          | 122  | 11.1 | 77                      | 122  | 10.4 | 72                          | 121  | 9.8 |
|                    | 2600 | 78                          | 120  | 10.6 | 73                      | 119  | 9.9  | 68                          | 118  | 9.4 |
|                    | 2500 | 70                          | 115  | 9.6  | 65                      | 114  | 9.0  | 60                          | 112  | 8.5 |
|                    | 2400 | 62                          | 109  | 8.6  | 57                      | 108  | 8.2  | 54                          | 106  | 7.7 |
|                    | 2300 | 54                          | 103  | 7.8  | 51                      | 101  | 7.4  | 48                          | 99   | 7.0 |
|                    | 2200 | 48                          | 96   | 7.1  | 45                      | 94   | 6.7  | 43                          | 92   | 6.4 |

Figure 5-8. Cruise Performance (Sheet 1 of 2)

CESSNA  
MODEL 172S

SECTION 5  
PERFORMANCE

## SHORT FIELD LANDING DISTANCE AT 2550 POUNDS

### CONDITIONS:

Flaps 30°  
Power Off  
Maximum Braking  
Paved, level, dry runway  
Zero Wind  
Speed at 50 Ft: 61 KIAS

| Press<br>Alt<br>In<br>Feet | 0°C                |                                          | 10°C               |                                          | 20°C               |                                          | 30°C               |                                          | 40°C               |                                          |
|----------------------------|--------------------|------------------------------------------|--------------------|------------------------------------------|--------------------|------------------------------------------|--------------------|------------------------------------------|--------------------|------------------------------------------|
|                            | Grnd<br>Roll<br>Ft | Total<br>Ft To<br>Clear<br>50 Ft<br>Obst | Grnd<br>Roll<br>Ft | Total<br>Ft To<br>Clear<br>50 Ft<br>Obst | Grnd<br>Roll<br>Ft | Total<br>Ft To<br>Clear<br>50 Ft<br>Obst | Grnd<br>Roll<br>Ft | Total<br>Ft To<br>Clear<br>50 Ft<br>Obst | Grnd<br>Roll<br>Ft | Total<br>Ft To<br>Clear<br>50 Ft<br>Obst |
| S. L.                      | 545                | 1290                                     | 565                | 1320                                     | 585                | 1350                                     | 605                | 1380                                     | 625                | 1415                                     |
| 1000                       | 565                | 1320                                     | 585                | 1350                                     | 605                | 1385                                     | 625                | 1420                                     | 650                | 1450                                     |
| 2000                       | 585                | 1355                                     | 610                | 1385                                     | 630                | 1420                                     | 650                | 1455                                     | 670                | 1490                                     |
| 3000                       | 610                | 1385                                     | 630                | 1425                                     | 655                | 1460                                     | 675                | 1495                                     | 695                | 1530                                     |
| 4000                       | 630                | 1425                                     | 655                | 1460                                     | 675                | 1495                                     | 700                | 1535                                     | 725                | 1570                                     |
| 5000                       | 655                | 1460                                     | 680                | 1500                                     | 705                | 1535                                     | 725                | 1575                                     | 750                | 1615                                     |
| 6000                       | 680                | 1500                                     | 705                | 1540                                     | 730                | 1580                                     | 755                | 1620                                     | 780                | 1660                                     |
| 7000                       | 705                | 1545                                     | 730                | 1585                                     | 760                | 1625                                     | 785                | 1665                                     | 810                | 1705                                     |
| 8000                       | 735                | 1585                                     | 760                | 1630                                     | 790                | 1670                                     | 815                | 1715                                     | 840                | 1755                                     |

### NOTES:

1. Short field technique as specified in Section 4.
2. Decrease distances 10% for each 9 knots headwind. For operation with tail winds up to 10 knots, increase distances by 10% for each 2 knots.
3. For operation on dry, grass runway, increase distances by 45% of the "ground roll" figure.
4. If landing with flaps up, increase the approach speed by 9 KIAS and allow for 35% longer distances.

Figure 5-11. Short Field Landing Distance

Revision 4

5-23/5-24

**Appendix I**

**Situational Awareness Questions**

How much fuel do you have left onboard: one quarter, one half, or three quarters, or a full tank?

How far away, in miles, is your next waypoint?

What is your current heading?

In case of an emergency landing, in which direction is the nearest airport?

What is your current altitude?

What is the maximum elevation figure for your current location?

What is your current airspeed?

## **Appendix J**

### **Debriefing**

Thank you for participating in this experiment. The purpose of this study is to examine the effect of musical ability on pilot performance characteristics such as flight planning, situational awareness, and flight path deviations. Participants were divided into two groups: one whose participants have previously received musical training, and one without. You were asked to create a flight plan, fly a simulator, and answer situational awareness questions. The flight plan will be measured by deviations from the provided route. The flight simulation will be measured by deviations from the provided course. Situational awareness will be measured by accuracy and time required to answer the question. Your score will be averaged into your groups score in an effort to find a difference between musically trained and non-musically trained pilots. Data collected from this experiment will help further develop research in both music and aviation fields. This research could provide an understanding of how musical ability can predict performance in flight training academy.

In an effort to find the truest results, we ask that you refrain from discussing this experiment with your peers. If you would like your data removed from this experiment, you may do so by e-mailing Andrew Henry at [HenryA10@my.erau.edu](mailto:HenryA10@my.erau.edu). Regardless if you wish to have your data removed from this study, you will be awarded \$10.00 for your participation in the study.

If you have any questions or wish to receive a copy of the final report, you may e-mail Andrew Henry at [HenryA10@my.erau.edu](mailto:HenryA10@my.erau.edu)

Thanks again!